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Improved Bates Laboratory Aspirator[1]

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INTRODUCTION

Many cereal, rice, and seed-testing laboratories, including the laboratories of commercial processing plants in which sample analyses are required, often have need for an air-separating device for removing lightweight material from samples that are to be tested. Among such laboratories may be mentioned the laboratories of agricultural experiment stations that need such a device for cleaning the seeds that are obtained from row plots; protein laboratories for removing lightweight foreign matter from grain samples on which protein tests are to be made; seed laboratories for cleaning and separating seeds which lend themselves to air treatment; milling, malting, and cereal laboratories for cleaning laboratory samples that are to be tested; rice inspection laboratories for removing shelled loose hulls, lightweight seeds, and other foreign material from samples in the official inspection and grading of rough rice and in the rough-rice-milling tests; and rice mills for detecting loss of rice in the hulls and the polish.

The improved Bates laboratory aspirator meets these needs. It is a device designed for separating granular substances by means of a controlled current of rising air which is passed through the substances as they fall in a thin stream.

[1] This circular supersedes Circular No. 9, THE BATES LABORATORY ASPIRATOR, which was issued in 1927 as a contribution from the Bureau of Agricultural Economics. In July 1939, the work on grain standardization, inspection and grading was transferred to the Agricultural Marketing Service.

The late George P. Bodnar collaborated in the preparation of the publication in 1927.

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A public patent (No. 1,524,012) for the aspirator has been granted to E. N. Bates by the United States Patent Office. This permits the manufacture and the use of the patented article in the United States by any citizen of the United States without the payment of royalty.[2]

Principles of Separation by Air

In using air for separating granular substances the size, shape, and weight of the substances determine what may be accomplished in the way of making separations. For example, within practical limits particles of the same size and shape may be separated with respect to their weight by the use of the aspirator; again, particles of the same size and weight may be separated on the basis of their shape; and, third, particles of the same shape and weight may be separated on the basis of their size. In approaching the problem of separating granular substances by means of an air current it should be realized that although the theory of air separation appears simple there are practical difficulties which, to a degree at least, must be overcome.

The thoroughness of separation made possible by the use of air currents depends to a large degree upon the rate of flow of the material into the air stream and the velocity of the air current. Because of the high fluidity and elasticity of air it is very difficult to produce a current of air that will have a uniform velocity throughout the entire cross section of the air stream. Any solid substance that enters a stream of air offers resistance to its flow. Unless the particles to be separated by the air current are evenly distributed throughout the entire cross section of the stream of air there will be a tendency for the air velocity to increase at those parts where the particles are the fewest and the resistance is least, and to decrease in those parts where the particles are the most numerous. Such an unbalanced air current tends to result in poor separation. The necessity for a constant, even feed of the material being cleaned is therefore evident. In the aspirator described in this circular both the rate of feed and the air velocity can be controlled.

DESCRIPTION OF THE ASPIRATOR

The aspirator may be made of brass or galvanized iron. It occupies a space approximately 22 by 10 inches and is 28 inches high. The total weight of the device (including the motor) is about 25 pounds.

The capacity or rate of cleaning by the aspirator varies with the quality, kinds, and combinations of the materials on which separations are made.

The aspirator is composed of the following parts: Receiving hopper, feed-control mechanism, aspirating chamber, hopper for receiving the discharged coarse, heavyweight material, connecting passage from aspirating chamber to cyclone, cyclone separator, flexible transparent cup for holding the lightweight material discharged from the cyclone separator, suction fan and motor, a carbon disk rheostat to

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[2] For a description of a different form of the aspirator to be used as an attachment to a threshing separator for cleaning grain, rice, and other seeds at the time of threshing as a part of the threshing operation, see BATES, E. N., BODNAR, G. P., and BALDWIN, R. L., CLEANING GRAIN WITH THE BATES ASPIRATOR, U. S. Dept. Agr. Misc. Cir. 56, 21 pp., illus. 1926.

control the motor voltage, a voltmeter to read the motor voltage, an electric switch, a valve in the connecting passage for controlling the velocity of the air, and the mounting or support for the entire apparatus (figs. 1 and 2).

The receiving hopper which holds the material to be aspirated has a volume of approximately 3 quarts dry measure, equivalent to about

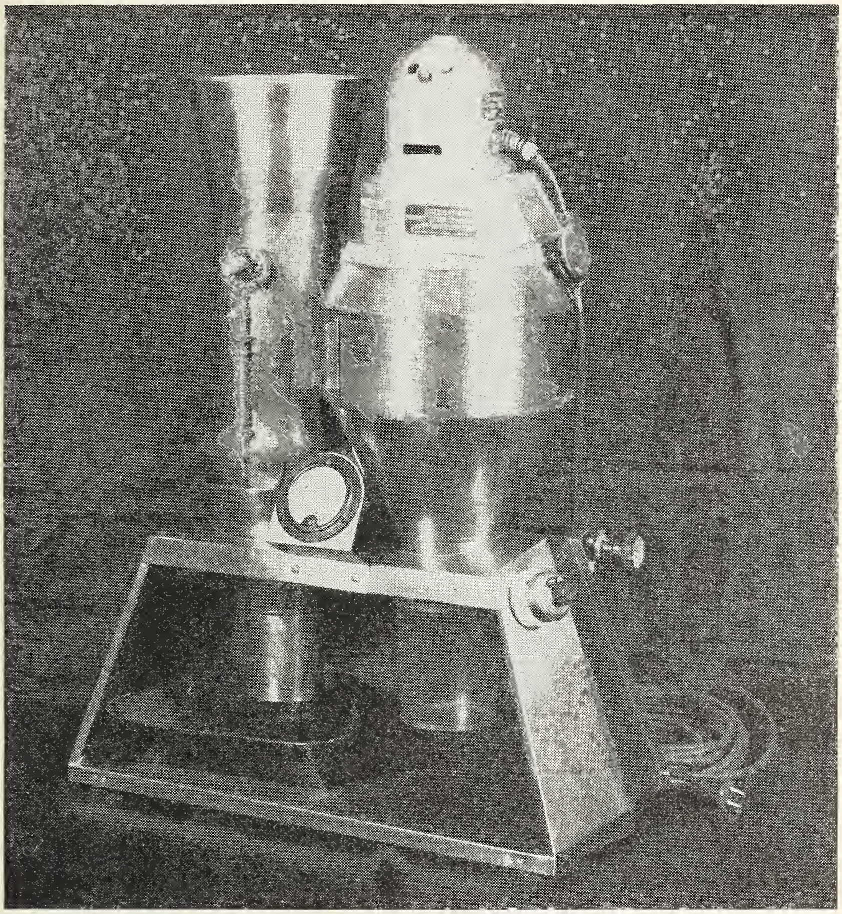

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FIGURE 1.—Improved Bates laboratory aspirator equipped with rheostat and voltmeter for adjusting suction.

5 pounds (2,268 grams) of wheat. The material to be aspirated flows into the aspirating chamber by gravity through an opening which is controlled by the feed valve at the lower end of the hopper.

The feed-control mechanism consists of a graduated eccentric dial, a J-shaped iron rod, a coiled spring, and a cone valve which also acts as a distributor for the material being aspirated. The adjustable part of the mechanism, the setting of which regulates the rate of flow of the material being aspirated, is conveniently mounted on the front

of the outer cylinder which forms the receiving hopper and aspirating chamber.

The funnel-shaped hopper, into which the aspirated material falls from the aspirating chamber, affords a means of collecting and directing this material into a receiving pan which must be placed under

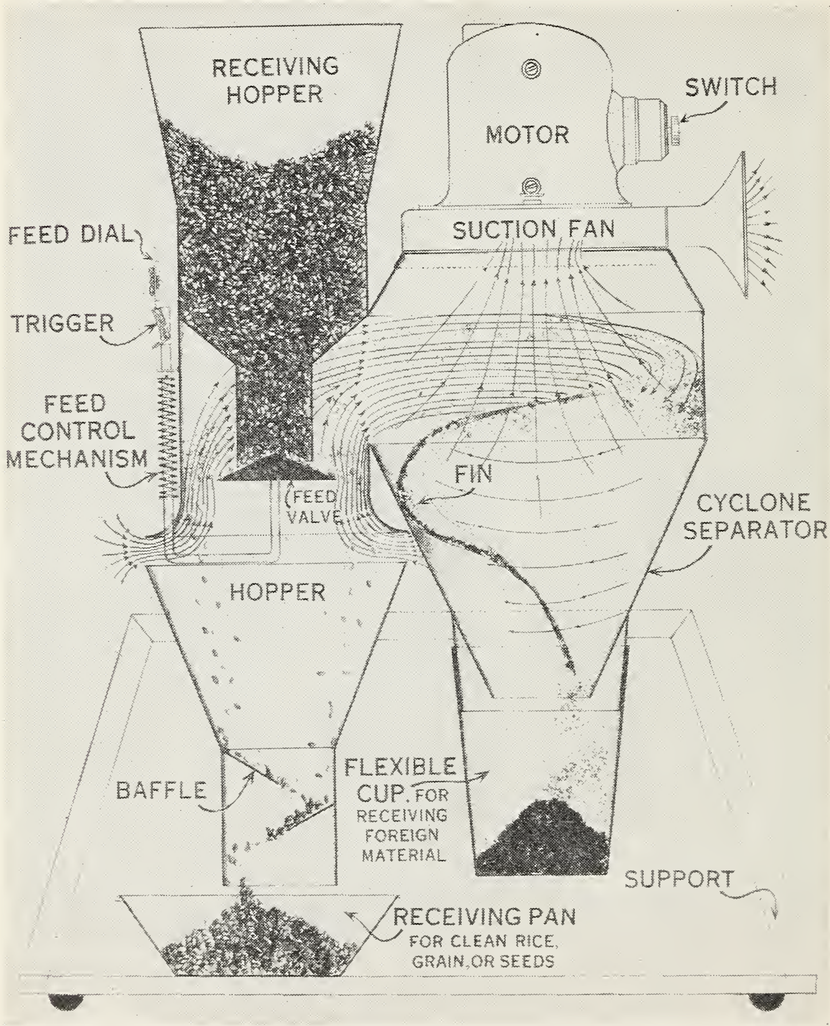

FIGURE 2.—Cross section of the Bates aspirator, showing the path of the air and material as it passes through the device. The air-control valve can be seen in figure 1.

the outlet of the hopper before the feed valve is opened. On opposite sides of the cylindrical part of the hopper two sloping baffle plates are soldered, one above the other. The purpose of the baffles is to break the fall of the material and thus prevent the kernels from bouncing out of the receiving pan.

The lightweight particles which are removed from the stream of the material being aspirated are carried by the air current through a short connecting passage which directs the material into the cyclone separator at a tangent to the inside cylindrical part of the cyclone separator.

The air-control valve is shaped to fit the outer surface of the cylindrical part of the cyclone separator and slides around the cylinder, either opening or closing the air inlet to the cyclone separator, thus regulating the velocity of the air that is applied to the material which is being aspirated. A scale in quarter inches drawn on the upper valve guide indicates the relative opening of the valve.

Improved regulation and control of aspiration may be had through reducing the motor speed by means of a carbon-disk rheostat in the line and by a voltmeter to indicate the reduced voltage impressed on the motor for any aspiration set-up desired. There are a number of advantages in motor-speed regulation through the use of a carbon-disk rheostat which varies the motor speed evenly (not in steps), thus producing even changes in the suction which performs the aspiration. By opening the air valve wide and controlling the suction by reducing the speed of the motor, better aspirating results are accomplished and the noise and the wear of the motor are reduced and the electric energy used is less. Also, through the combined adjustment of motor voltage and air-valve setting, an ideal means is had of a very delicate adjustment of suction as well as an accurate means of repeating any suction condition regardless of possible fluctuations in line voltage.

The cost of a satisfactory carbon-disk rheostat and universal voltmeter installation is approximately $20.

The function of the cyclone separator is to separate the solid particles from the air. This is accomplished by the centrifugal force of the rapidly rotating air inside the cyclone separator, which throws the particles that are in the air outward against the inner surface of the cyclone separator. To the inside of the cyclone separator is attached a spiral fin which forces the rapidly revolving material downward through the lower outlet of the cyclone separator and into the cup below. The clean air from which the particles of material have been separated is drawn out of the cyclone separator by the fan.

A transparent plastic, tapered, flexible cup receives the lightweight solid material that has been separated from the air in the cyclone separator. A metal collar tapered to fit the inside of the top of the cup is permanently attached to the lower part of the cyclone separator. When the cup is pressed firmly in place the connection is strong enough to hold the cup in position and is practically airtight.

The suction fan and motor unit used is of the vertical-axis vacuum-sweeper type. Viewed from above, the fan rotates in a clockwise direction.

OPERATION OF THE ASPIRATOR

When the aspirator is in operation the rice, other grains, flaxseed, grass, or forage seeds, or other material to be cleaned flows from the receiving hopper in a thin, even sheet over the edge of the feed valve cone into an upward moving current of air. The velocity of the rising air rushing through the falling sheet of material is adjusted so that it will lift out and carry with it the particles of material that are

light in weight compared with the particles in the main part of the sample. The kernels of rice, other grains, flaxseed, or other seeds, as the case may be, which are too heavy to be lifted out by the rising current of air, continue to fall through the hopper into the receiving pan that is placed below the hopper.

The lightweight particles that are lifted out of the falling stream of material are carried with the air through the connecting passage into the cyclone separator, thence into the transparent cup below it.

Making Aspirator Adjustments

To ascertain the best aspirator feed valve, air valve, and voltage settings for the separation of any definite kind of material, let it be assumed that a sample is to be aspirated for which all the aspirator adjustments will have to be found by experiment. A procedure somewhat as follows is suggested:

Put a quart or two of the material to be aspirated in the receiving hopper with feed valve closed. Set the air valve tentatively at what is judged to be a slightly wider opening than will be needed. Start the motor and turn the rheostat to give approximately 80 volts, which will cause a light suction.

To adjust the feed valve loosen the clamping screw of the dial and slowly rotate the dial in a clockwise direction until its edge presses the trigger on the feed valve down to a position that allows a thin, even stream of the material to flow from the receiving hopper, and then clamp the feed dial in that position. Now, increase the voltage to produce the desired separation. If the voltage required is more than about 105 volts, readjust the air valve to the next higher marked position so it can be seen whether the air is carrying into the transparent cup a noticeable quantity of the heavier particles.

When the machine is thus operating, and while watching closely the type of material coming into the transparent cup, slowly reduce the aspirating suction by lowering the voltage on the motor until the desired separation is obtained. Now, close the feed valve by pressing upward on the trigger arm, thus disengaging the trigger from the dial and allowing the feed valve to close without disturbing the dial setting, and stop the motor.

Thoroughly mix together the materials in the receiving pan and the transparent cup, and return the mixture to the receiving hopper. Return the pan and the cup to their places and start the motor. Start the feed by pressing down on the trigger arm until it again engages the edge of the dial. Allow the sample to run through the aspirator at this setting. Stop the motor and carefully examine both parts of the separation. If the separation is not at first satisfactory by rerunning the sample at a higher or a lower voltage as the case may require, a voltage and air-valve setting will be finally arrived at that gives the best results.

It is suggested that a permanent record be made, giving the kind of grain or seed, the type of material that is separated from it, the air- and feed-valve setting, and the voltage used. When another sample of this character is to be aspirated, the settings of feed, air, and voltage can all be made before the feed of the sample is started,

and the desired results should be obtained the first time the sample is passed through the aspirator.

Running the aspirator at voltages below 60 will be unnecessary and undesirable. When such low voltages appear to be desirable, the same aspirating results can be had by reducing the air-valve opening and increasing the voltage.

When the motor of the aspirator is run for a long period at a reduced voltage, it will be noted that at the beginning of the period the voltage appears to drop slowly. This is the result of the increasing temperature of the carbon disks of the rheostat. When the temperature of the rheostat becomes steady, the voltage will remain steady.

In operating the aspirator, it has been noticed that the very last of a sample to flow from the machine does not receive the same aspiration that the main part of the sample receives. This is due to the fact that the last flow from the receiving hopper is drawn into the aspirating chamber with a rush of air through the partially uncovered feed opening as the receiving hopper is emptied and this new air passage reduces the rate of air flow at the aspirating point. This objectionable end effect can be overcome by returning a small quantity of the aspirated material to the receiving hopper just before it becomes empty. The material for this use is taken from the receiving pan without stopping the aspirator; thus the end effect will have no significance as it will occur on the material that has already been aspirated.

Small samples must be given a slightly different treatment than samples of normal size. In passing a small quantity of any material through the aspirator it has been found that the best results are obtained by dribbling the sample through the machine from a pan rather than by feeding it through with the feed mechanism. By dribbling is meant slowly pouring the material into the receiving hopper with feed valve open, thus allowing a small stream of material to flow into the air stream. If the pan from which the sample is being poured is allowed to rest on the edge of the receiving hopper during the pouring, the vibration of the machine produces an even and regular flow of material.

A clogging of the feed valve caused by the accumulation of particles considerably larger than the average size of the material for which the valve was set may be relieved by pressing down suddenly on the trigger arm, thereby enlarging the feed opening for an instant so as to permit the obstacle to pass the feed valve. Upon being released, the valve returns immediately to its previous setting.

APPLICATION OF ASPIRATOR TO RICE, OTHER GRAINS, AND OTHER SUBSTANCES

An Aid to Hand Picking

Frequently in the laboratory analyses of rice, other grains, and seeds it is necessary to obtain a portion of a sample or a lot of the rice, grain, or seeds that is absolutely free from all other grains, or seeds, or foreign material. Such purity of samples usually can only be assured by hand picking. Hand picking of large rice, other grains,

and seed samples is a tedious, slow, and eyestraining task. Much of the time and the strain of hand picking rice, other grains, and seeds can be eliminated by the judicious use of the aspirator.

The following procedure is suggested for using the aspirator to facilitate the hand picking of rice, other grains, and seed samples.

After dividing the sample by means of a Boerner divider to assure the representativeness of the portion that is to be hand-picked, run the portion through the aspirator which has been so set that it will remove only the fine and lightweight foreign material from the sample. The fine and lightweight material so removed will consist only of material that may be considered as foreign to the rice, other grains, or seeds being analyzed. The portion of rice, other grains, or seeds being tested may then be run a second time through the aspirator with the air suction increased to the point where practically all the remaining foreign material in it is lifted out along with a small quantity of the smaller or shrunken rice, grain, or seed kernels. Each of these last two separations will have to be hand-picked to complete the cleaning operation. The saving in time and effort comes from the lessened work of hand picking the few large pieces of foreign material left in the portion of the sample that is being tested, and the hand picking of the relatively small number of whole kernels from the usually small separation containing the remainder of the foreign matter. The process can be varied to suit the situation presented by each particular sample but usually good results are obtained by two aspirations, one light and one heavy, of the sample being analyzed, thus segregating and concentrating the foreign material in small portions of the sample.

Cleaning Rice and Other Grains for Seed With the Laboratory Aspirator

The laboratory-size aspirator was not designed for continuous operation as a rice, grain, or seed cleaner, but for cleaning a few bushels of seed rice, other seed grains, or other seeds even a laboratory-size aspirator can be used to advantage. When using the aspirator for cleaning seed the necessary frequent stopping of the operation to empty the cup of lightweight material can be avoided by allowing the receiving cup and the cyclone separator to become filled with foreign material. The cyclone collector then becomes inoperative and the foreign material is blown out through the fan. If the aspirator is located in a place where it is not feasible to blow the lightweight material out into the air, when continuous operation is desired, provision should be made for the fan to discharge this material into a large, porous bag or settling chamber. For continuous operation the average capacity of the aspirator is approximately 10 bushels of wheat or rice, or other grains, per hour, and its time limit of operation would be that imposed by the motor installation.

Rough Rice

The United States Department of Agriculture prescribes the aspirator as part of the standard laboratory equipment for the inspection and grading of rough rice, and in making milling tests of California-Japan rough rice.

In the grading of rough rice, a sample of the rice is put through the Smith shelling device to remove the hulls from the kernels, then the shelled rice is passed through the Bates laboratory aspirator for the removal of the loose hulls. In this way an accurate determination can be made of the percentages of rice and of hulls in a sample. Figure 3 shows rice hulls removed by the aspirator from shelled rice. By the use of the aspirator it is possible to make a separation of the hulls and the rice kernels without the loss of the finely broken particles of the rice kernels. Many of the broken particles are lost when the hulls are "blown" from a rubbed portion.

In the milling of rice the principal byproducts are bran, polish, and hulls. The hulls are of little commercial value but are frequently used as fuel at the mill where they are produced. Rice bran

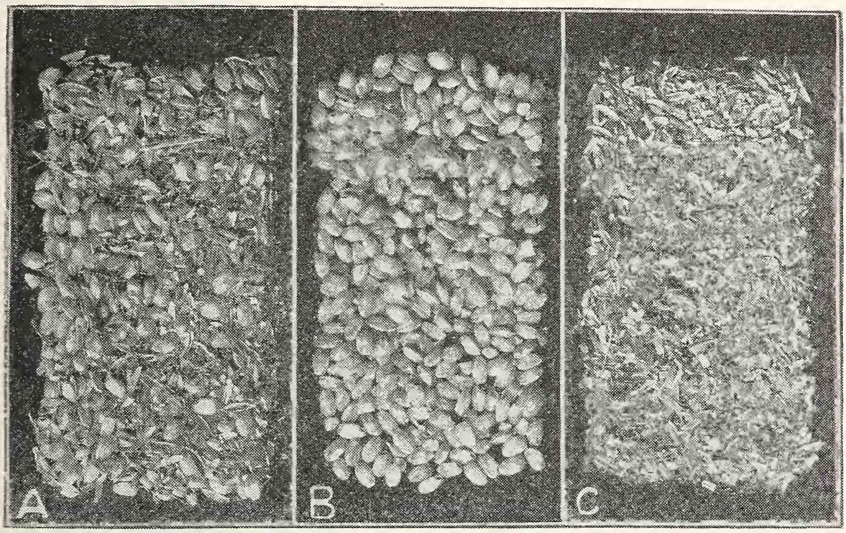

FIGURE 3.—Rice cleaning with the laboratory aspirator: *A*, Rice as obtained from a Smith shelling device; *B*, the same rice after being cleaned with the laboratory aspirator; *C*, the type of material removed from rice.

and rice polish are sold for stock feed. Consequently, if any whole or broken kernels of milled rice become mixed with the hulls they are a total loss. If either whole or broken kernels become mixed with the bran or the polish, a monetary loss is sustained for the reason that any broken rice that goes into the bran or the polish will be sold as bran or polish for about one-half its value as whole or broken rice.

The sample to be analyzed should first be weighed. Then after the separation of hulls, bran, and polish, the reclaimed rice should be weighed. From the difference the monetary loss per day as a result of selling broken rice as bran or polish can easily be computed. Where the test shows the loss of rice to be significant, the milling machinery can be immediately adjusted.

The aspirator is especially well adapted for removing immature and blighted rough rice kernels, some kinds of weed seeds, and other

lightweight foreign material from seed rice. These factors have a material influence on the value of rice for seed purposes. The percentage of such material in a sample of seed rice is readily determined by means of the aspirator.

Cleaning grain or seed with air alone is usually a compromise between using a light suction which leaves some of the foreign material in the cleaned grain or seed, with little or no grain or seed being carried over into the foreign material that is removed, and using a heavy suction which leaves practically no foreign material in the cleaned grain or seed but with more grain or seed being carried over into the foreign material that is removed. Circumstances will determine which strength of suction should be used in any grain- or seed-cleaning work. Figures 4 to 8, inclusive, show average laboratory-aspirator cleaning of several kinds of rice, other grains, and seed.

Wheat

From wheat (fig. 4) the aspirator removes light smut balls, pieces of smut balls, spores of smut, chaff, stems, pieces of straw rachis, and many kinds of weed seeds.

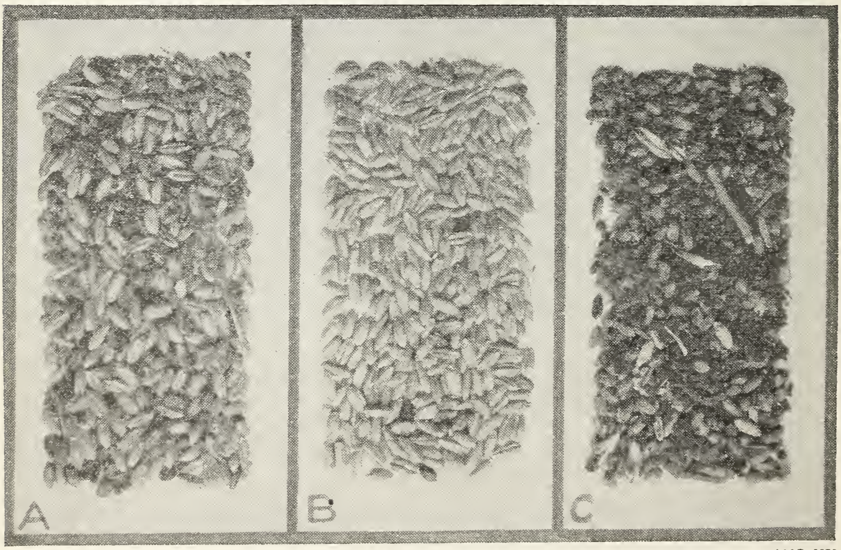

Figure 4.—Wheat cleaning with the laboratory aspirator: *A*, Smutty wheat as received at market from LaMar, Wash.; *B*, the same wheat after being cleaned with the laboratory aspirator; *C*, the type of material removed from the wheat, consisting mostly of smut balls and pieces of smut balls.

Oats

From oats the aspirator removes loose oat hulls, chaff, unfilled oats, many "pin" oats, weed seeds, and lightweight foreign material.

White Clover Seed

From white clover seed (fig. 5) the aspirator removes pieces of leaves and broken stems.

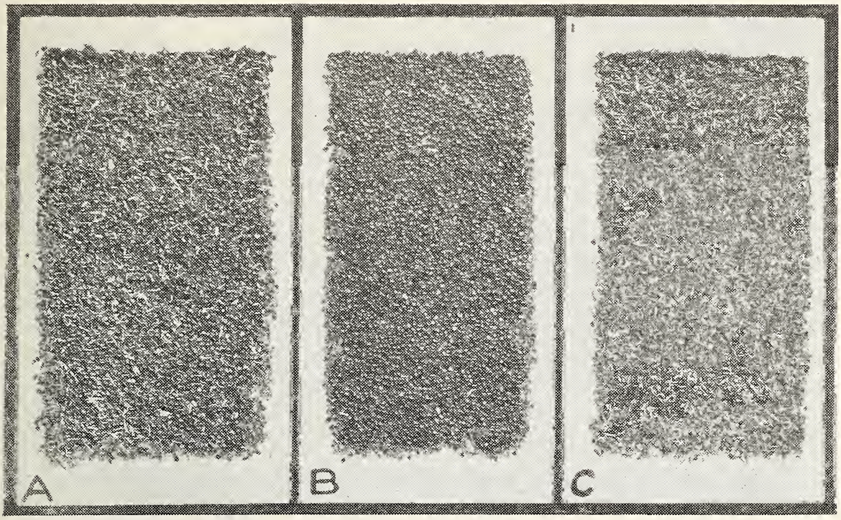

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Figure 5.—White clover seed cleaning with the laboratory aspirator: *A*, White clover seed as received from a threshing machine in Crook County, Oreg.; *B*, the same seed after being cleaned with the laboratory aspirator; *C*, the type of material removed from white clover seed.

Vetch

From vetch (fig. 6) the aspirator removes wild oats, chess, stems, pieces of pods, broken stems, and thistle seeds.

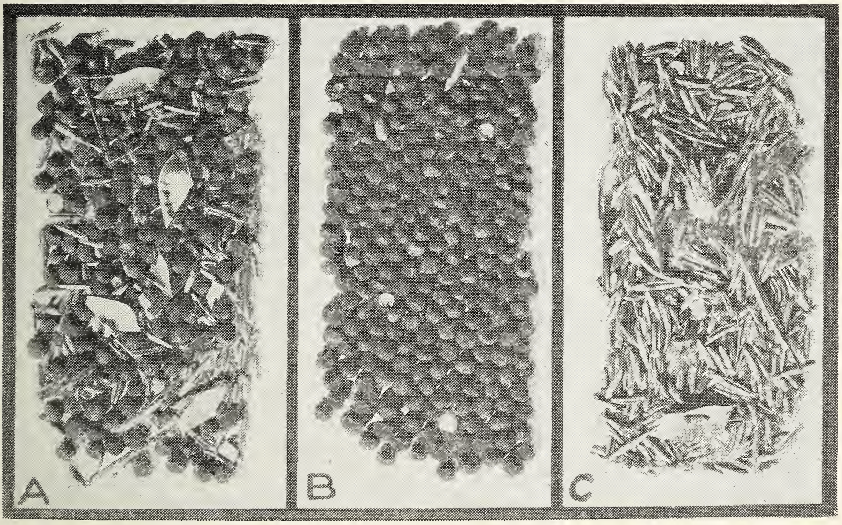

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Figure 6.—Vetch cleaning with the laboratory aspirator: *A*, Oregon vetch containing a type of foreign material frequently found in vetch as threshed; *B*, the same vetch after being cleaned with the laboratory aspirator; *C*, the type of material removed from vetch.

Flaxseed

From flaxseed (fig. 7) the aspirator removes pieces of leaves, stems, pods, and other lightweight substances.

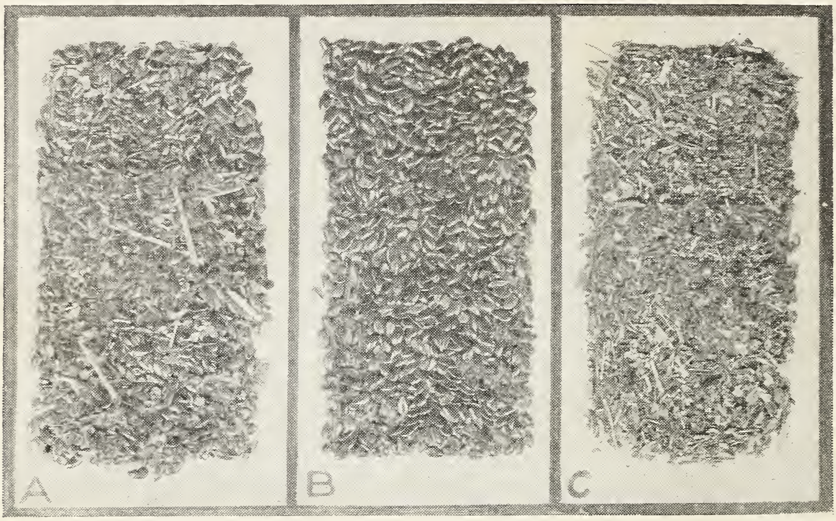

Figure 7.—Flaxseed cleaning with the laboratory aspirator: *A*, Volunteer flaxseed grown at Vancouver, Wash.; *B*, the same flaxseed after being cleaned with the laboratory aspirator; *C*, the type of material removed from flaxseed.

Barley

From barley (fig. 8) the aspirator removes loose hulls, pieces of straw, broken beards, wild radish pods, weed seeds, and very thin barley kernels.

Figure 8.—Barley cleaning with the laboratory aspirator: *A*, California barley containing a type of foreign material found in threshed barley; *B*, the same barley after being cleaned with the laboratory aspirator; *C*, the type of material removed from barley.

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